Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

MODE OF FORMATION OF TILL AS ILLUSTRATED BY THE KANSAN DRIFT OF NORTHERN ILLINOIS.

PERHAPS at no time during the Quaternary era were the climatal conditions of Illinois of such a nature as to originate a glacier independently of the ice introduced into the territory by outflow from the vast *névé* to the northeast. Consequently, when near the culmination of the Kansan epoch, a very early representative of the Lake Michigan glacier overspread nearly the whole of the territory of the present state of Illinois, it advanced across a region in which the indurated rock was but thinly covered by a nearly continuous mantle of residuary material, mostly clay, sand and angular gravel; and the ice thereupon proceeded to manufacture this into till. In a part of northwestern Illinois, especially in Stephenson county, the glaciation was of short duration and never repeated, and this district therefore, presents one of the best fields for the study of the contact phenomena between the base of the glacier and the preglacial land surface. There are scattered over the area incomplete deposits representing every stage in the process from solid rock to typical till. By a careful study of these imperfectly formed masses of till we may infer the process by which the ice manufactured the residuary material and underlying rock into the various types of deposits due directly to glacial action. The necessarily limited nature of this paper will compel me to state the hypothesis which seems to best explain the phenomena known to me, and simply refer to the localities where each stage is illustrated, mentioning a few of their most significant features.

The ice, in advancing across Stephenson county, moved westwardly, and within fifteen miles of the Driftless Area, in a decidedly northwesterly direction. During this time of general advance, glacial abrasion was at a minimum, and had the ice then melted from this district, without further movement, its drift phenomena would be insignificant and uninteresting. But it so happened that, during the general recession of the glacial front, there were repeated slight readvances, forming a peculiar variety of incipient moraine, consisting of knolls and short ridges of angular limestone débris and of stratified water-worn gravel and sand. Between the marginal accumulations of a distinctly morainic type, there are other deposits of somewhat similar nature, but which belong to the so-called ground moraine. In other words, the period of most pronounced glacial action in the Kansan epoch in northern Illinois, occupied a position considerably later than the culmination of the epoch. This I attribute to a milder climate, causing a recession of the ice-front, but yet giving more free movement to the glacier and softer material to work upon. I have gone into this short explanation of the glacial history of Stephenson county, so as to exactly locate the age of the deposits the significance of which I propose to discuss.

We may gain some idea of the condition of the surface previous to the arrival of the ice by a study of a north-south belt along the eastern boundary of Stephenson county, and about thirty miles back from the glacial boundary. Here we will find frequent exposures of the semi-decayed upper portion of the Galena limestone with its overlying undisturbed residuary clay.[1] The Galena formation is usually a heavy-bedded, sub-crystalline dolomite, shaly in certain thin layers and extensively jointed and fissured. Within ten to fifteen feet of the surface, weathering has opened certain deposition-planes, separating the rock into layers from two to four inches in thickness. As the rock is composed of small rhomboidal crystals, the next stage of decay consists of a solution of the bond between the crystals resulting in a loose mass of angular grains, macroscopically resembling fine yellow sand. By a continuance of the process the crystals are dissolved, leaving a slight residue which, accumulating to a thickness of two to ten feet, becomes a highly oxidized, dark red, very fine-grained, structureless clay. Certain layers of the dolomite abound in chert, which breaks up into angular fragments, averaging about the size of a walnut. These abound in the residuary clay, and on hillsides often pass horizontally from the solid rock into the red clay, with but little disturbance of the lines of stratification. This is one of the strongest proofs of the undisturbed nature of the residuary clay at the localities previously mentioned. In fissures and pit-shaped holes in the surface of the rock, the red clay may extend down from ten to thirty feet. This particular form of its occurrence can be observed in almost any rock-cutting in the county.[1]

---

[1] This is finely displayed in a road cutting one mile south of Egan in Ogle county, and in an excavation of the Chicago and Great Western railway, two miles east of German Valley in Stephenson county.

1. The first effect of the contact between the base of the glacier and the mantle of residuary clay, was a rearrangment of the latter. It was pushed forward and downward, but as its downward progress was limited to a slight compression, the effect was a crushing or kneading of the mass. The faint evidence of stratification in the undisturbed deposit furnished by the layers of chert, was totally destroyed and the fragmental chert scattered indiscriminately through the mass. All deposits of rearranged residuary clay are referred to this stage when they contain no foreign material whatever. As they, in many cases can be proven to have been moved but a very short distance, their transportation and deposition were clearly exclusively subglacial.[2]

---

[1] For a thorough discussion of the residuary material accumulating over the Galena limestone in unglaciated areas, the reader is referred to CHAMBERLIN and SALISBURY'S excellent report on the superficial geology of the Wisconsin Driftless Area in the Sixth Annual Report of the U. S. Geological Survey.

[2] A careful study of the county of Stephenson would probably afford several hundred localities — of very limited extent, however — where the process of till making was stopped in this first stage. Good exposures can be found by following the C. G. W. R. R. from South Freeport to Egan, or the I. C. R. R. from Feeeport to Everts. Another, exposed in a small ravine on the south side of Yellow creek, is important from the fact that the rearranged residuary cherty clay has been pushed off of its original rock ridge onto the surface of a lake deposit.

2. The process in the second stage is merely a continuation of the last. The material has been transported farther, kneaded longer and more thoroughly commingled. In addition, a small percentage of foreign drift, mostly well-rounded pebbles of small size, has been worked into the deposit. Still, at the completion of this stage, the fine-grained, dark red clay basis and predominance of angular white chert indicate the close relation between this very incomplete till and the undisturbed residuary material. This is the nature of the ground moraine over practically the entire northern half of the county. But in looking for exposures of it, it is necessary to remember that the upper three feet of the typical or completed till in this district have been highly oxidized during the following interglacial epoch, so that in color they often resemble the deposits of stage No. 2. The latter never were of any other color than dark red and reddish brown.[1]

The mode of transportation of this imperfectly formed till appears to have been exclusively subglacial. In a very large proportion of exposures in Stephenson county, there is a continuous section from an undisturbed preglacial residuary clay, through every gradation to what may be considered typical of the "semi-residuary" class of drift. There is absolutely not an iota of evidence that any of this material has been lifted from the earth's surface and enclosed in ice. Clear evidences of a kneading or rolling over of the mass are abundant.

3. There existed under the glacier, certain areas where deposition was being carried on at the same time that abrasion was active in others. So that, while in many portions of the county, the manufacture of till was carried into the second stage only, on certain closely adjoining areas this was but the beginning or early stage of the glacial action. In these latter, the ice after having removed the red clay, proceeded to attack the loose sand-like mass of dolomite crystals, which it quickly disposed of by incorporating with the deposits of stage No. 2, furnishing their first

---

[1] This red till is best exposed in several cuttings of the I. C. R. R., about three miles southeast of Winslow, in Stephenson county.

supply of calcareous material. A few sections show it interstratified with till, and it can sometimes be traced back to its original undisturbed position.[1] Having been transported but a score or at most a few hundreds of feet, there is no room for anything but subglacial action.

We have disposed for the present of all the loose material on the surface of the solid rock, and we now come to the most interesting part of the process.

4. Stephenson county is a comparatively hilly region, although the hills are not high, steep, or close together. A section through a hill would show the Galena limestone as a series of practically horizontal layers, not cemented, but held in position by gravity and the projections on the upper and under surfaces of the layers. The ice in moving westwardly across the country, upon ascending the eastern slope of a hill from which the loose material had been removed, exerted a powerful pressure on the edges of these layers. Near the top of the hill, the pressure overcame the friction, and the upper layers of the rock were pushed forward, sliding on a lower unmoving stratum. In many cases, these transported rock ledges were not broken up, but moved forward as a solid mass, being found in that condition to day. They may be ten or fifteen feet in thickness, and several hundred feet in length, and perfectly horizontal, so that the fact of their not being *in situ* would not be known were it not for their unusual position, partially obstructing valleys, producing a topography radically different from the preglacial; and from their overlying drift of various kinds, including stratified water-worn gravel; and more often than otherwise underlain by loose angular gravel from ten to thirty feet in thickness.[2] In transportation they were clearly pushed in front of or under the extreme marginal portions of the ice. None of them have been removed far from their original position, and this with much

---

[1] Small exposures of it, after being disturbed but before being combined with the red clay, may be seen at nearly every outcrop of the latter, notably in the railway cuttings of the southeastern part of the county.

[2] Locality where best exposed — six miles east southeast, of Freeport, in a high ridge, on the north side of the I. C. R. R.

other evidence, negatives the idea that the basal portion of the glacier "plucked" these huge masses of rock from the ridges and transported them in its body.

Sometimes the pressure of the ice resulted only in a slight folding, or a tilting and faulting of the rock strata without moving them to a distance from their original position. This may affect them to a depth of twenty or thirty feet, and may include some of the solid, heavy-bedded, unweathered layers. In these cases, at least, no question can remain that the action was extra-glacial or marginally subglacial. Their importance lies chiefly in the fact that they prove beyond dispute that even the Kansan ice-sheet could, at times, exert powerful forward pressure on the rock over which it moved.

5. The forward movement of the unbroken rock mass was rarely continued many scores of yards before some obstruction was encountered, often in the form of an upward slope of the land, increasing the friction to such a degree that the transported ledge was unable to withstand the pressure and general fracture resulted.[1] In a few cases, the impression made on the observer is that the mass remained unbroken while the stress accumulated, until, becoming too great, the entire ledge was suddenly fractured into innumerable small angular pieces, under a well-known principle recognized as a condition of the formation of certain limestone breccias in various portions of the earth. Usually, however, there is clear evidence of a kneading or rolling over and crushing of the mass, producing an internal structure which cannot be simulated by the product of any other known process. When a series of semi-decayed or loosely compacted strata being forced forward in front of the ice, are checked by some obstruction, they tend to corrugate in a manner somewhat similar to the Appalachian type of mountain building; and the disturbance is greatest in the vicinity of the obstruction. But when the ice

---

[1] The deposits representing this stage are quite numerous in the Pecatonica basin, over an area about three miles in diameter, lying immediately southwest of the village of Dakota, and another west of the village of Everts. They are usually in the form of dome-shaped knolls and short ridges, and forming conspicuous features of the drift topography, it is unnecessary to more minutely describe their localities.

overrides the deposit, if the basal friction is great enough, it will turn up the strata in contact with it, twist them over on to the as yet undisturbed strata, and inaugurate a motion in the mass which may be not inaptly compared to the movement of a roller under a heavy weight. Rarely, however, will the actual action be as perfect as it should theoretically be, but usually there is combined with the rolling process a forward and downward thrust which crushes the mass. The more resistant portions of the ledge break into huge angular blocks, the semi-decayed layers into smaller fragments intermingled with a great quantity of calcareous sand. The rolling is obviously produced by the "drag" of the forwardly moving glacier, while the thrust is the result of its great weight. This kneading process is not only theoretically probable, but has given rise, as I have already intimated, to phenomena in Stephenson county, Illinois, which are explainable only under the supposition of having been produced by its action.

6. By a continuance of the kneading process, the larger blocks are crushed, all evidences of the original lines of stratification are destroyed, and the deposit for the first time bears a slight resemblance to certain very stony tills. Few of the particles are smaller than the crystals of which the original limestone was composed, and, therefore, the deposit may still be classed with the "transported rock ledges." Moreover, in this stage there are practically no foreign rock fragments although a few Canadian pebbles may be found imbedded in it far from the surface, proving its glacial age.[1]

7. The process of manufacture between the last stage and the typical glacial till may proceed along several lines. all similar in the general features of the method, but differing in details. Several deposits along the Galena road, one mile northwest of Freeport, and along the C. G. W. R. R. between German Valley and Egan, seem to represent a stage slightly in advance of that just described. Here the angular limestone débris is com-

---

[1] A deposit representing this stage is finely exposed in a gravel pit, one mile north of Freeport, where the angular gravel overlies water-worn drift gravel.

mingled with a considerable quantity of rounded drift of which a large portion consists of Canadian bowlders. The foreign material may reach as high as 50 per cent. of the mass, but usually falls below 10 per cent. The bowlders belong to the "englacial" drift, and the deposits containing them are marginal, but I introduce them here because by a marked readvance of the glacial front, they may be reworked into till.

8. In other cases, the ice was transporting the red, imperfectly formed till, described under stage No. 2, contemporaneously with the angular limestone débris, and they often came in contact, either becoming thoroughly commingled or perhaps only interstratified. When the intermingling is complete, the deposit has the appearance of a very stony till of a light brown color, and the material of which is evidently mainly of local derivation.[1]

9. Just previous to the incursion of ice into the Pecatonica basin, in Stephenson county, its area was occupied, at the lower levels, by several successive extra-glacial lakes, which deposited glacial silts, some of which resemble typical loess, and others a modified or water deposited till. During the glaciation of the region, the abrasion of these comparatively soft silts was remarkably small, yet sufficient to leave an impress on the character of the till which now overlies them. For it is observed that, while the ground moraine over the northern half of the county, where these silts were poorly developed and rarely reached by the ice, is very similar in color and texture to the residuary clays, over the southern third of the county, where the land lies lower and the extra-glacial silts were strongly developed, the ground moraine is in general of a quite different character. The marginal deposits are similar in both districts (consisting largely of angular limestone débris and stratified water-worn gravel and sand), but on the inter-incipient-morainic tracts in the southern district, there is often seen a till identical in all important respects with that which is exposed in long and repeatedly glaciated regions

---

[1] Typically developed along the road between Egan and Lightsville in Ogle county, about two miles north of the latter village.

and which I have referred to as "typical till." It is a stiff, unstratified, light yellowish gray clay, containing irregularly disseminated subangular blocks, largely of local derivation, but also an appreciable percentage of foreign rock fragments, many of which are Canadian in origin. The Niagara limestone pebbles are next in abundance to the Galena limestone and chert, and are often beautifully striated. A belt of this variety of glacial clay occupies the country between Yellow creek and a high upland area about four miles south of it. Its eastward and westward limits are indefinite, but its length may properly be included within ten miles. It can be observed best by proceeding due south from Freeport, where at the distance of about four miles, it will be seen to assume distinct drumloid characters. In particular, one of these *pseudo* drumlins, while it has a core of stratified sand and gravel, is overlain by an eight-foot stratum of yellow till so nearly identical in constitution with the typical till of a highly glaciated region, that no appreciable difference could be detected. This drumlin (?) is also the best locality in this county for securing finely striated stones. Now, a careful study of the composition of this till belt shows that, (*a*) the mass of its clay may be referred to abrasion of the silt formations which it frequently overlies: (*b*) its foreign rock fragments must have been brought into the district by the ice-sheet, but independently of the accumulation of the till, their occurrence in which is an accident of deposition; (*c*) the iron in the till was derived from the residuary clay of the region, as was also the large amount of angular and subangular white chert; and (*d*) the subangular Galena limestone blocks which are quite abundant but generally overlooked because of the more attractive appearance of the foreign drift, must have been derived from the country rock, very close to its present position, by the process which has been described in this paper.

It may be objected to the first proposition that the difference between the till in this limited belt and that in the remainder of the county, may be due to a greatly increased introduction of foreign material along some line as the broad, shallow basin which occupies the southern third of the county. The existence of this basin I recognize as the cause of the much larger proportion of foreign drift pebbles in its vicinity, for it favored subglacial transportation of them, but I do not think it alone can explain the phenomena connected with the above described belt of typical till. For (1) when we go east on the line of glacial movement, the characteristics of this till disappear, and in the extreme eastern portion of the county, what little till we do find in the Pecatonic basin, is mostly of the very imperfectly formed "semi-residuary" variety; and (2) if we study the limits of this characteristic till belt and the direction of ice movement, in connection with the limits of the main body of the extra-glacial lake clays and silts, we find such a relation between them as to clearly indicate the derivation of a large portion of the former from the latter.

In short, the composition of the till in the belt now under discussion, points to its being only a stage in advance of that described under stage No. 8, this advance being due chiefly to the introduction of a large amount of clay and silt, the result of an accidental passage of the ice over a semi-plastic lake deposit, which resisted erosion comparatively well, but yet suffered some abrasion at its surface. Therefore, as the yellow till occurs over and in the immediate vicinity of the stratified clays, there is no room for an englacial transportation, which is, moreover, quite unnecessary, and in opposition to the comparative abundance of striated pebbles.

In summarizing the evidence presented in the preceding pages, I would subdivide the product of direct glacial action, in the central Pecatonica basin, into classes as follows:

CLASS I. Semi-residuary drift. Till composed largely of rearranged red residuary clay and chert, with comparatively few foreign pebbles.

CLASS II. Angular local limestone débris. Varies between contorted, tilted, and transported unfractured rock ledges, and fine limestone breccia.

CLASS III. Consisting largely of a combination of the two preceding with the addition generally of Canadian pebbles and small bowlders. Usually seen in marginal deposits.

CLASS IV. Typical till. Light yellow gray calcareous clay containing pebbles and small bowlders of local and foreign derivation, many of the latter beautifully striated.

The divisional lines between these classes, in the Pecatonica basin, must always be arbitrarily placed, as there are gradations from those deposits which are typical of one class to those which are typical of another. There is, also, no definite rule in their distribution for, while the four classes evidently represent four successive general stages in the process of manufacturing typical till, and should, therefore, naturally be expected to occupy successive belts from the outer glacial boundary back or east, they are in reality scattered indiscriminately over the entire district. However, Class I prevails in the northern half of the county; Class II in a north and south belt which, extending across the county, has its western boundary on a meridianal line which passes a few miles west of Freeport, and dies away to the east near the Winnebago county line; Class III prevails over a belt several miles in width extending diagonally from the southeastern corner of the county to near Freeport; and Class IV is principally developed south of Yellow creek, over and near to the remnants of the Lake Pecatonica clays.

Perhaps the most remarkable feature of the drift of this county is its anomalous distribution. Over the western one-third of the county, the drift, although comparatively thin, is generally distributed. Over the central belt, the evidence of vigorous glacial action is strongest. While in the extreme eastern one-fourth of the county, which was glaciated longest, there is very little drift of any kind, and there are areas, several square miles in extent, of nearly bare rock, and others where the preglacial residuary clay still remains undisturbed. It is evident that the conditions which controlled glacial action varied locally within wide limits, so that excessive abrasion of the rock surface might occur with a less weight of ice and a less length of glaciation, than on a neighboring area with similar topography would not suffice even to remove the residuary clay. When I make the statement that the four classes of glacial deposits discriminated in this district, occupy hills equally as high, as narrow, and as steep, also occupy valleys equally as deep and broad, and trending in the same direction, we are prepared to accept the following conclusions :

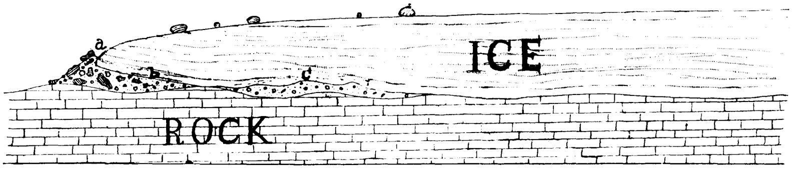

FIG. 1.—The Kansan ice at work in northwestern Illinois.

1. That certain glaciers, notably that which glaciated northwestern Illinois, in passing over a slightly hilly region, exerted very unequal pressure on the land surface, *this inequality not always being directly due to the topography of the immediate vicinity.*
2. In crossing hills of moderate height, they sometimes strongly abraded the crests, while on closely adjoining areas they deposited ground moraine on hills of similar height and shape.
3. The areas of maximum and of minimum glacial action were generally permanent, or approximately so, throughout the time of glaciation.
4. In studying areas in the Kansan drift region or at least that portion of it which is in northwestern Illinois, the relative length of the glaciation in different localities cannot be even inferred from the apparent severity of the glacial action.

In conclusion, I will state in more definite language what I conceive to have been the position with relation to the mass of the ice, of the unstratified drift of Stephenson county, Illinois. The derivation, transportation, and deposition of the material occurred mainly under the peripheral portion of the glacier. Here, through the thinning of the edge, the weight was less, and the force of the ice movement having decreased, there was a tendency of the extreme marginal portion to turn up, producing a base of a form somewhat as in the accompanying figure.

There was a struggle for the mastery between the advancing ice and the accumulating débris. The incipient morainic or marginal deposits of Stephenson county, including the transported rock ledges, belong to the extreme outer border of the ice and were transported least. Those which are most thoroughly kneaded belong to a position at about *b*. The drumlin (?) area south of Freeport may be placed at *c*, while much of the ground moraine was formed and deposited still farther back under the ice. By recession and repeated slight readvances of the ice-front, with a partial reworking of old deposits, the apparently indiscriminate distribution of the drift of this county may be accounted for. When the ice melted away entirely, the englacial bowlders which had become superglacial through ablation of the border portions of the glacier, and are so represented in the figure, came to rest upon the surface of all the other drift of the district and the areas of nearly bare rock represented at *a*.

If the advance was continued far, the ice overrode the coarse angular gravel at *a*, crushed it finer, brought up "semi-residuary" till and a little foreign drift from farther back, and combined them into typical till. This gradually fell behind the advancing border of the ice, and was redeposited as ground moraine, locally accumulating into drumlins and smoothly undulating drift areas, while the extreme outer portion of the glacier was forming a new deposit of angular local limestone débris.

OSCAR H. HERSHEY.

FREEPORT, ILL.,
January 5, 1897.